

A detailed 3D cutaway diagram of a particle accelerator, likely a synchrotron. The diagram shows various components including a central beam pipe, surrounding vacuum chambers, and complex support structures. Different parts are color-coded: a large green section in the center, red and blue sections on the right, and grey and white structural elements. The background is a light blue gradient.

Recent Updates from Software Meetings

Anthony Frawley (Florida State University)

Jin Huang (Brookhaven National Lab)

Michael McCumber (Los Alamos National Laboratory)

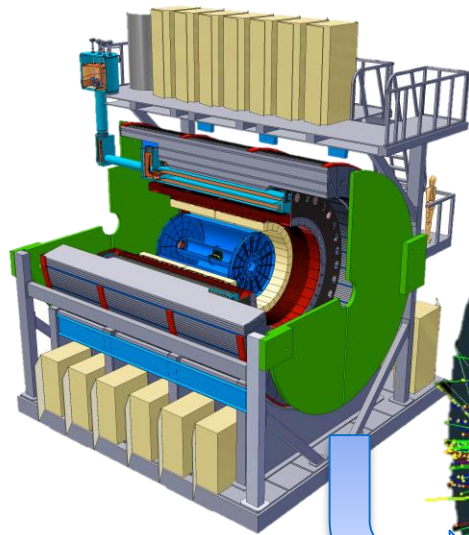
Chris Pinkenburg (Brookhaven National Lab)

Welcome to join Simulation/Software Meetings

- ▶ sPHENIX simulation/software meeting
 - weekly Tue 1PM @ BlueJeans & 2-219
 - Oct 4: tracking focused meeting
 - STAR tracking overview
Great discussion with STAR tracking team members, Gene Van Buren, Jérôme Lauret, Jason Webb, Victor Perevozchikov
 - ALICE and Olympus tracking (by Carlos P.)
 - Review components of sPHENIX tracking and planning
 - Oct 11: regular meeting
 - Upsilon projection with updated background (Sasha L.)
 - Dropbox Enterprise preview coming Oct 24 for 8 weeks (Martin P.)
 - Next: Oct 18 regular meeting
 - Expect update on fit GenFit2 (Haiwang Y.) → Silicon Ladder (Tony F.)
 - More topics e.g. Upsilon, HF-jet updates?
- ▶ TPC software meetings –Thu afternoons

sPHENIX tracking software

<https://github.com/sPHENIX-Collaboration/coresoftware>



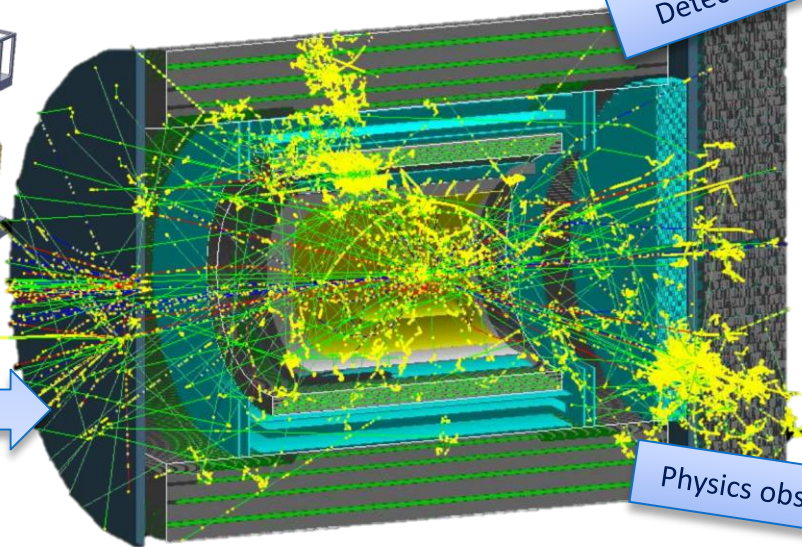
Ref. Design

- 3-layer MAPS
- 4-layers Silicon strip
- TPC (30-78 cm active)

→ G4 Simulation

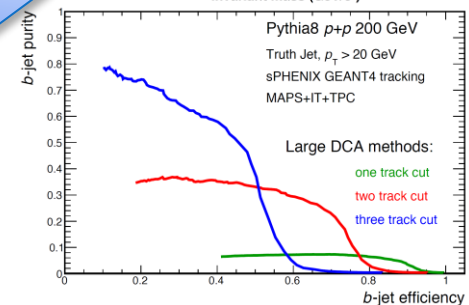
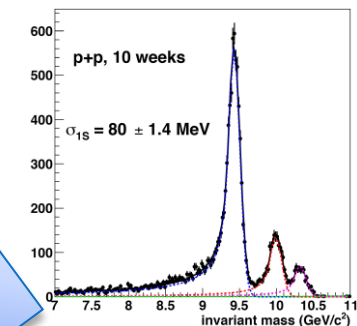
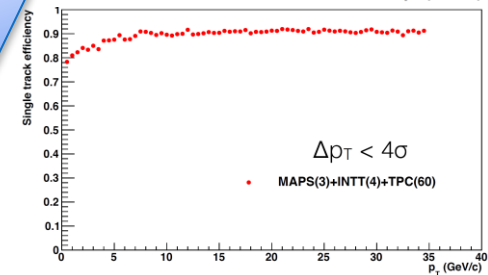
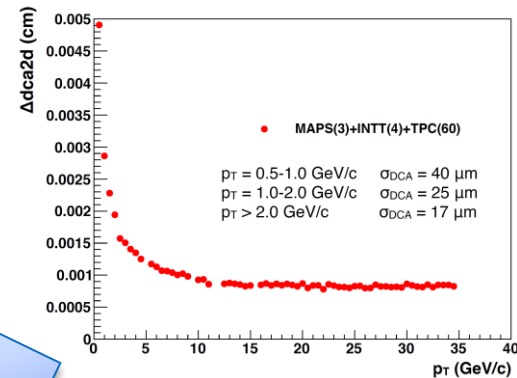
→ Digitization

→ Reconstruction →



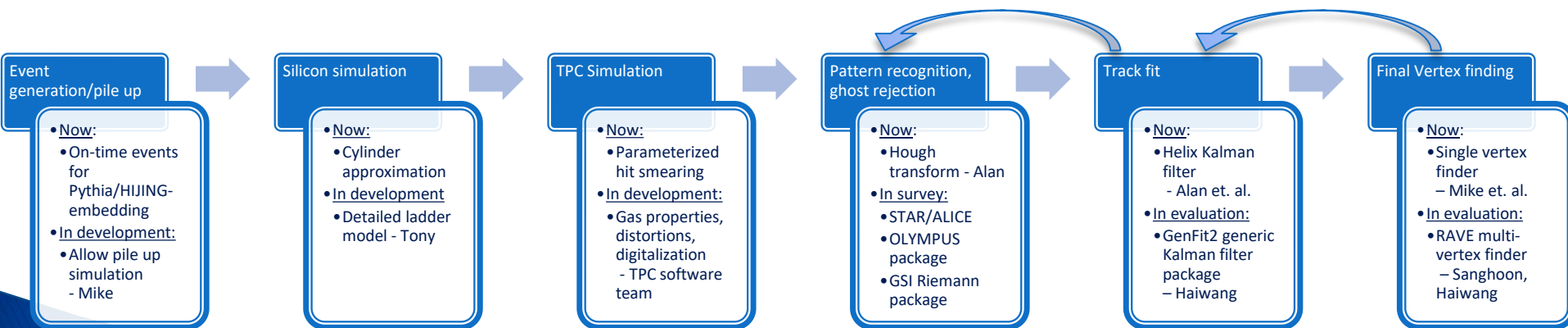
Detector performance

Physics obs. Projection



sPHENIX tracking simulation and reconstruction chain

- ▶ A chain of full detector Geant4 simulation and reconstruction software developed for sPHENIX, used in current detector and physics performance projection
- ▶ Limitations in current software that need to be evolved for the next stage
- ▶ Many new developments hold back before the Sept-tracking review. Now to be coordinated to be made default.



<https://indico.bnl.gov/conferenceDisplay.py?confId=1930>

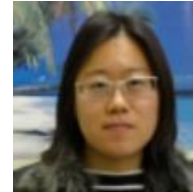
Plan for tracking software

- ▶ Pile up capability:
 - **Action Item [Mike]:** merge pile up support in event generation and digitization after cross check momentum resolution with Tony and clean up of vertex constraint
- ▶ Improve detector simulation:
 - **Action Item [Tony, Jin]:** pull request to merge ladder geometry on MAPS. Geometry file -> calibration database
 - **Action Item [Gaku]:** Build INTT ladder in Geant4 based on the existing chain of PHG4SiliconTrackerSubsystem -> PHG4SiliconTrackerCellReco -> common reco code
 - **Action Item [TPC team]:** Assign updated TPC size and gas material in the setup macros. Update distortion map with simulation of event fluctuation.
- ▶ Pattern recognition:
 - **Carlos** is testing OLUMPUS pattern recognition code
 - **Action Item [Sook Hyun, Sourav]:** test performance with an extended vertex z-window in the current Hough transform pattern recognition, as an attempt to allow tracking in multi-vertex
 - **Help welcomed:** Other pattern recognition packages under survey: STAR/ALICE Cellular Automata, STAR/Alice STV progressive finders , GSI Riemann package
- ▶ Track and vertex fitting:
 - **Action Item [Haiwang, Jin]:** pull request to replace track fitting with GenFit2.
 - **Action Item [Haiwang, Tony]:** pass the MAPS ladder normal direction to GetFit2
 - **Action Item [Haiwang, Sanghoon]:** verify quality of RAVE reconstructed event vertex by double checking the pull distribution. If good, pull request to replace silicon vertex fit with RAVE
 - **Action Item [Sanghoon]:** pull request to add new module processing a new vertex map to store secondary vertex found for tracks in given jet as used in B-jet tagging analysis



TPC software team

- Klaus Dehmelt
- Nils Feege
- Prakhar Garg
- Carlos Perez
- Veronica Roman
- Sourav Tarafdar



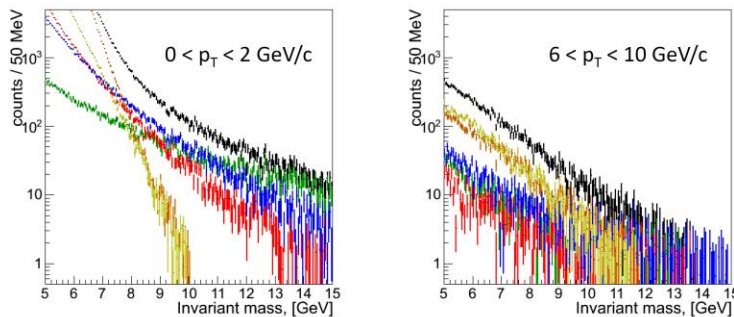
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Updates on Upsilon projections - Sasha Lebedev (ISU)



Background components in Au+Au vs. p_T (eID=0.7)

Yellow: fake e - fake e; Brown: fake e - HF;
Green: Drell-Yan; Red: Correlated charm; Blue: correlated bottom



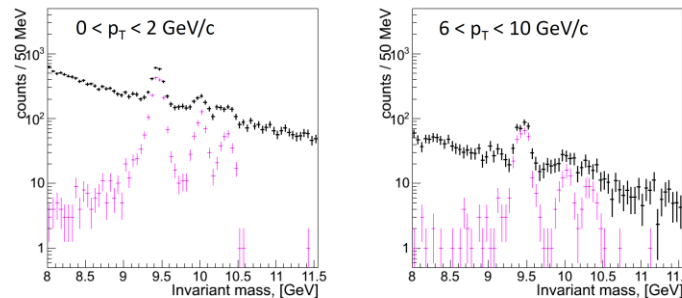
Updated hadron + 10% C embedding simulation with new reference detector simulation + momentum-dependent electron ID

+ Upsilon sim

Expected inv. mass in Au+Au vs. p_T

Signal/Background ratio is 0.5-1 for Upsilon(1S)

Same $R_{AA} = 1.0$ for all 3 states, eID = 0.7



Count Upsilon(1S) and in inv. mass range: 9.1-9.6 GeV

Next:

- Cross check R_{AA} with proposal
- Switch to higher eID eff. 90% working point

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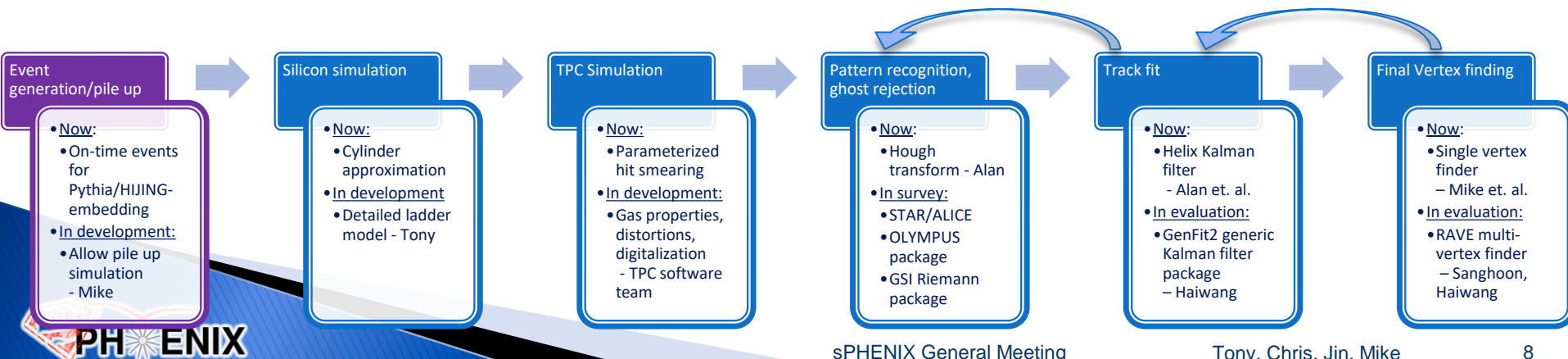
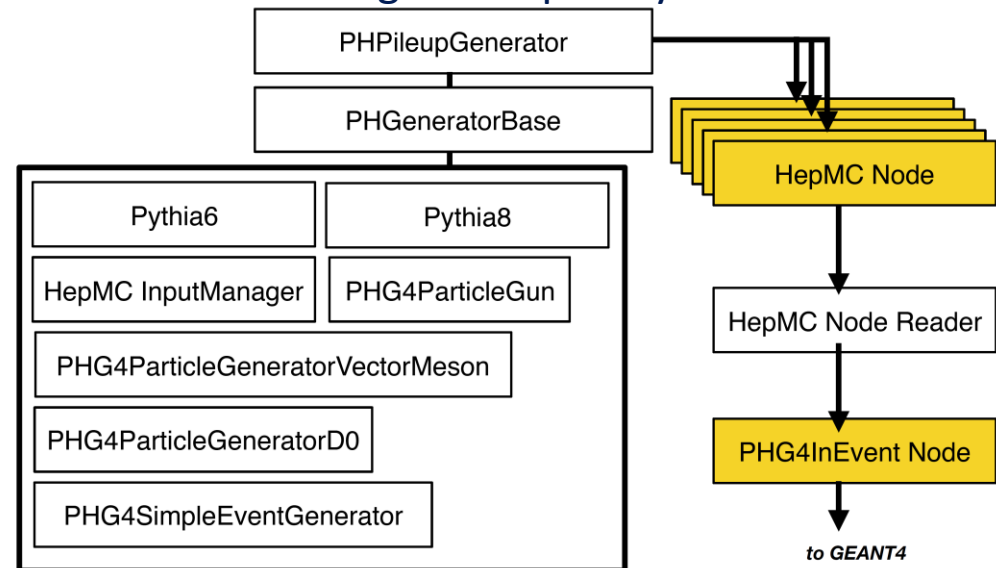
Extra information



Event generation with pile up support

- ▶ Pile up in event generation required for integrated detector simulation (TPC, MAPS)
- ▶ [In-development] Mike reworked on the event generator framework and digitization with timing dependence
- ▶ Talk by Mike today

New event generator framework as being developed by Mike McCumber



Silicon tracker simulation

► Geometry in simulation

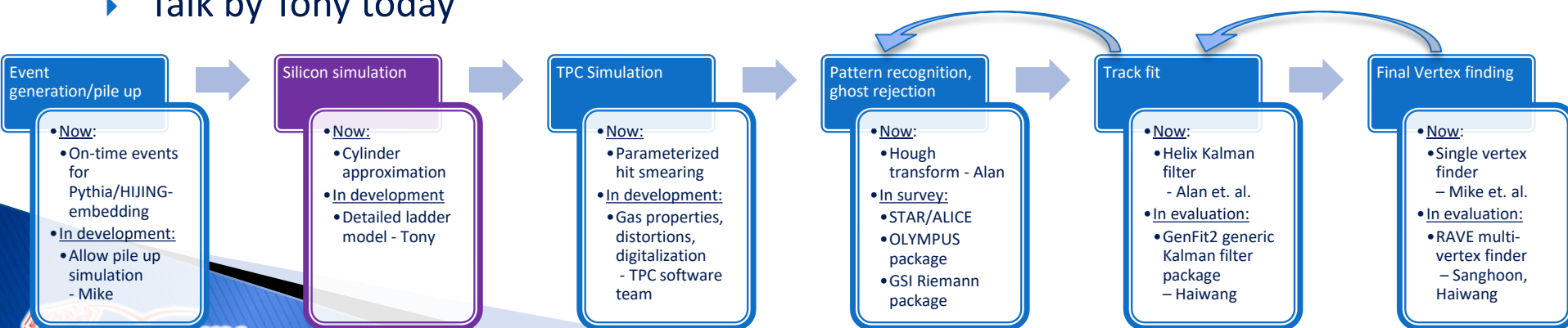
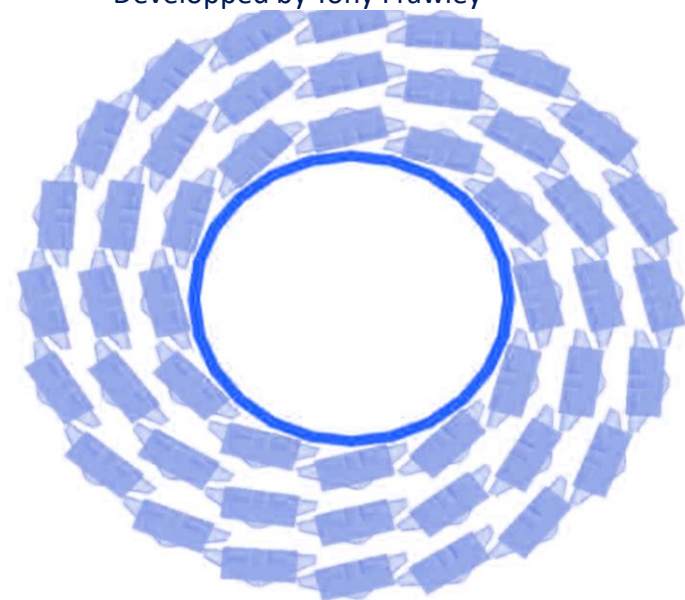
- [Default] Current silicon detector was simulated with cylindrical geometry (homogeneously distribute material in phi, one hit per layer). Dead-map simulation support
- [Ready to merge] Tony et al. imported ALICE ITS model in sPHENIX framework, close to completion.
- [Idea] Ladder modeling needed for INTT too
- **Require** patten recognition / fitting to match too (later slides)

► Digitization of silicon hit

- [In development] Translation of geometry to reconstruction
- [Idea] Charge diffusion and sharing

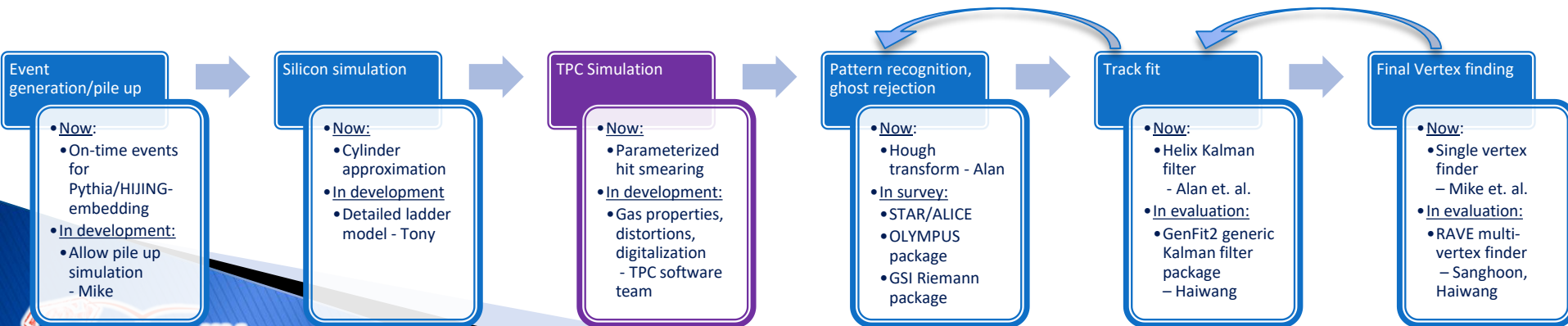
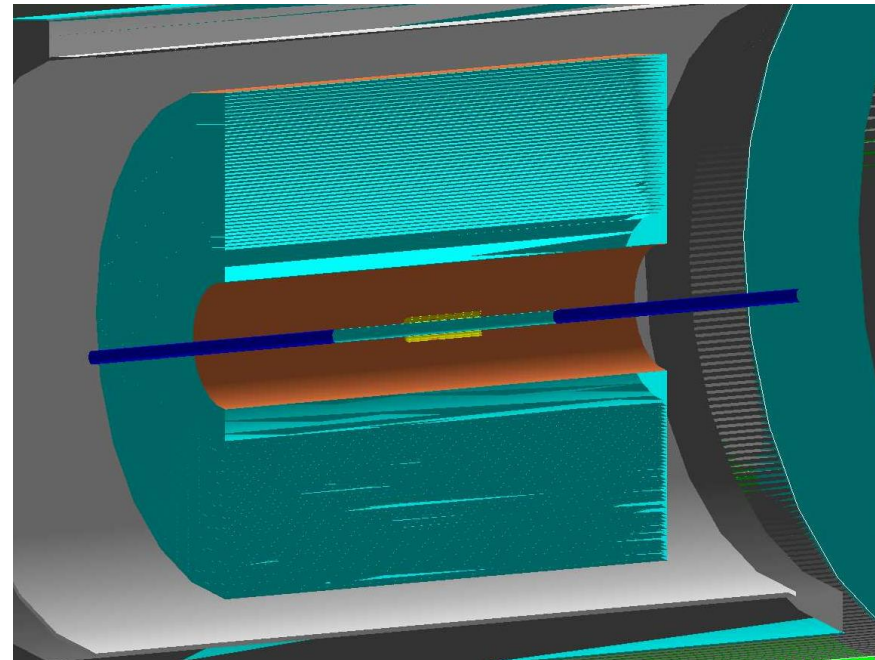
► Talk by Tony today

ITS ladder imported to sPHENIX sim
Developed by Tony Frawley



TPC simulation

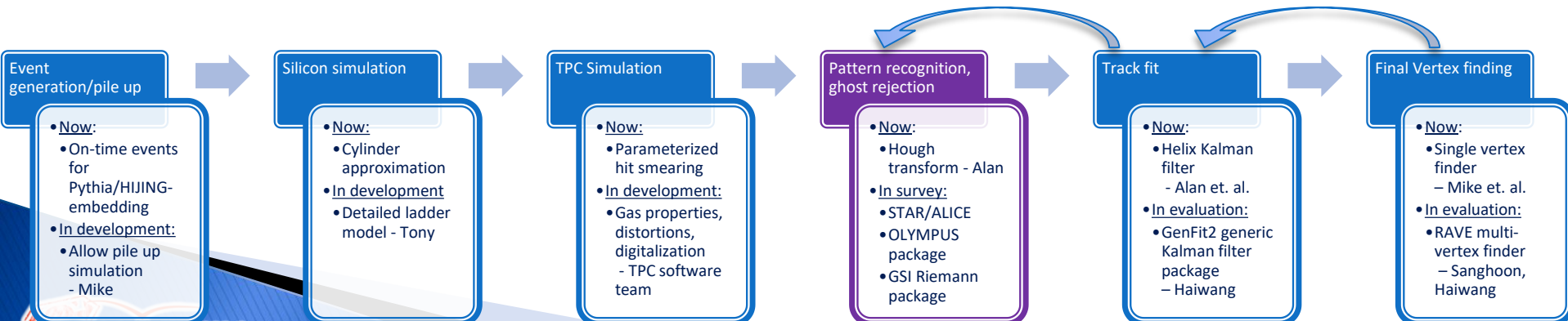
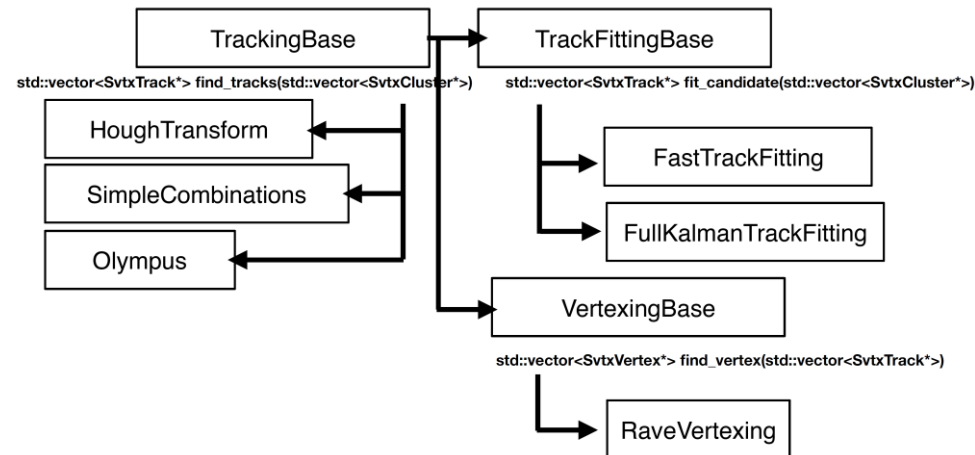
- ▶ **Now:**
 - Parameterized hit smearing
 - Apply residual distortion
- ▶ **In development:**
 - Many work on going by TPC software team
 - Geometry dimensions
 - Gas properties
 - Distortions from space charge and electric field
 - Signal digitalization.
- ▶ See Sourav's talk today



Pattern recognition and ghost rej.

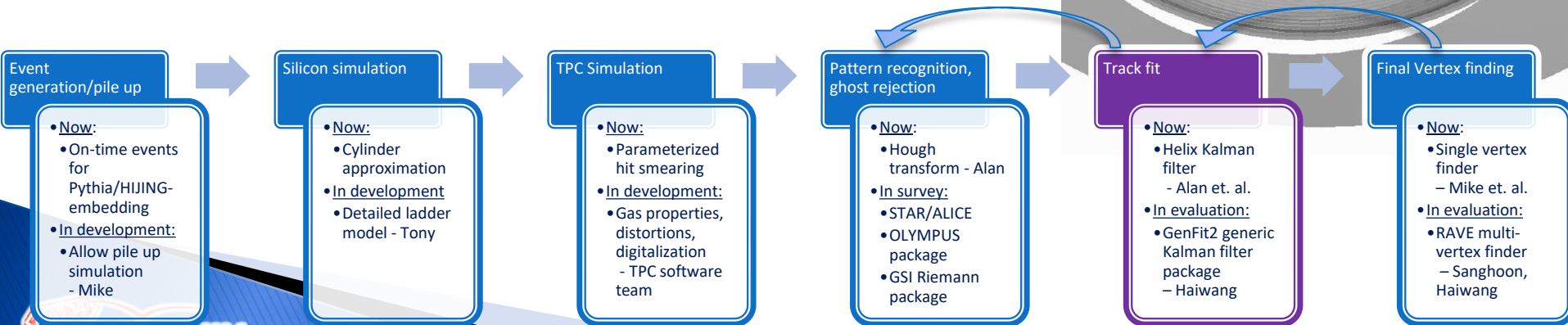
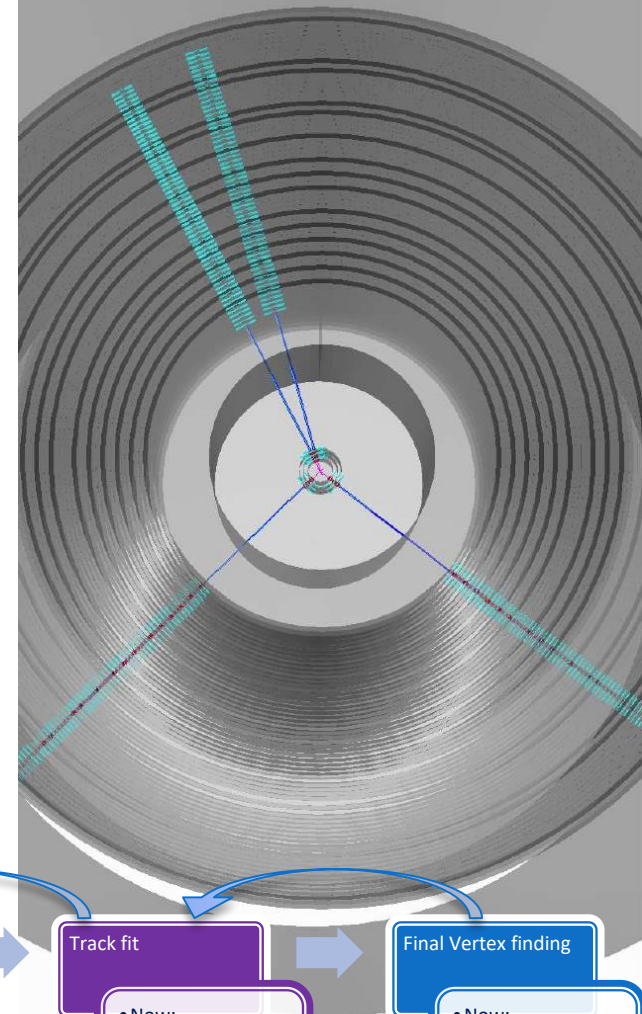
- ▶ **Default:**
 - Helix hough transform on cylindrical geometry-based detector, as part of **PHG4HoughTransformTPC**, by Alan Dion et. al.
- ▶ **In survey:**
 - STAR/ALICE
 - OLYMPUS package
 - GSI Riemann package
- ▶ **Proposal** to modularize patter recognition framework
- ▶ **Need manpower**

Proposal of modularized patter recognition framework by Mike McCumber



Track Fit

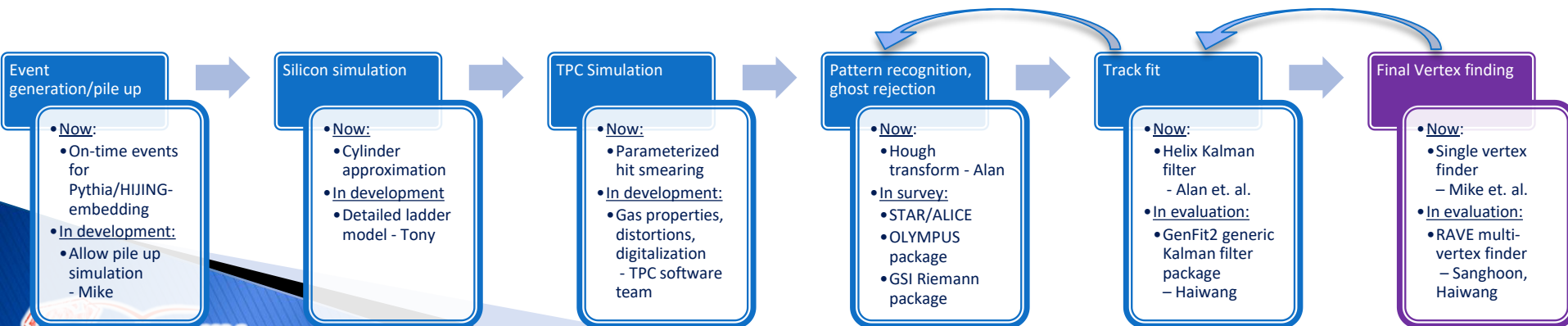
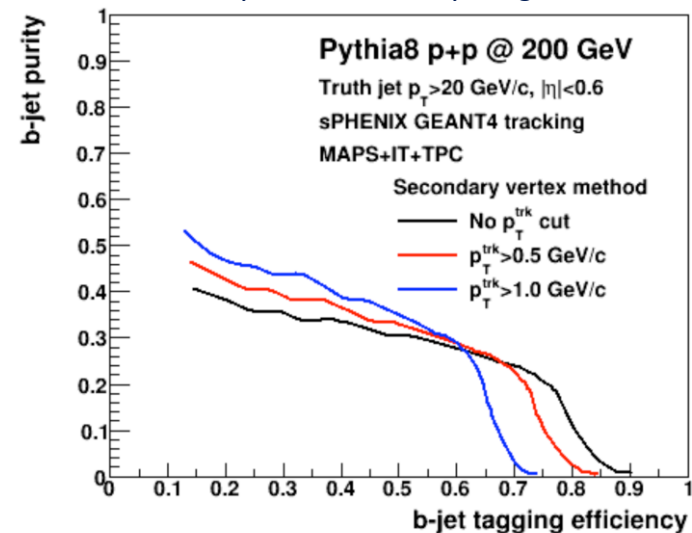
- ▶ **Default:**
 - Helix Kalman filter on cylindrical geometry, as part of **PHG4HoughTransformTPC**, by Alan Dion et. al.
- ▶ **Merged, not used by default : GenFit2**
 - A generic Kalman filter package developed at GSI, imported to sPHENIX by Haiwang Yu et. al.
 - Reproduce Helix Kalman filter results
 - Support G4 geometry import, therefore works for silicon ladders
 - Already use in b-jet tagging with 3D-DCA
 - Possibility to enable fake hit rejection for TPC
 - Talk by Haiwang today



Final vertex finding

- ▶ **Default:**
 - Single vertex finder and fitter as part of **PHG4HoughTransformTPC** by Mike et. al.
- ▶ **Merged, not used by default : RAVE**
 - A multi-vertex finder and fitter developed by CMS, imported by Sanghoon Lim and Haiwang Yu
 - Reasonably multi-vertex separation and fitting quality from initial test
 - Also adapted for analyzing secondary vertex in b-jets
 - Talk by Sanghoon today

B-jet tagging performance via secondary vertex finder by Sanghoon Lim



Interfaces to analyzers

- ▶ Available
 - Generalized track object
 - Evaluation tools for deep truth tracing
 - Standardized tracking QA tools
- ▶ In develop
 - [Merged, not used by default] Primary track fits by Haiwang Yu
 - [Pull request]: Reconstruction event display by Sook Hyun Lim
 - [Test code] DCA-3D fit by Haiwang Yu
 - [Idea] Toolkit to refit track DCA with user selected vertex using GenFit
 - [Idea] Improve toolkit for calorimeter projections using GenFit
 - [Idea] Toolkit for refit with PID assumptions other than pions

